Fermilab

SDC SOLENOID DESIGN NOTE #194

TITLE: Status of Cryogenic Design Study at SSCL

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This design note is one of a series which represents the proceedings of the SDC solenoid subgroup meeting held in Japan on December 8-11, 1992. The plan and purpose of the meeting was to:

- Look at the prototype coil winding and honeycomb vessel R&D in Japan
- Reports of technical progress from each group
- Plan and schedule for the prototype magnet assembly and test
- Discussions on design of the SDC solenoid power supply
- **Discussions on cryogenic design for the SDC solenoid**
- Discussions on responsibilities for the cryogenics fabrication
- Response to the report of the DOE review sub-committee
- Publications and presentations of the technical progress

SDC Solenoid Subgroup Meeting in Japan

Status of Cryogenic Design Study at SSCL

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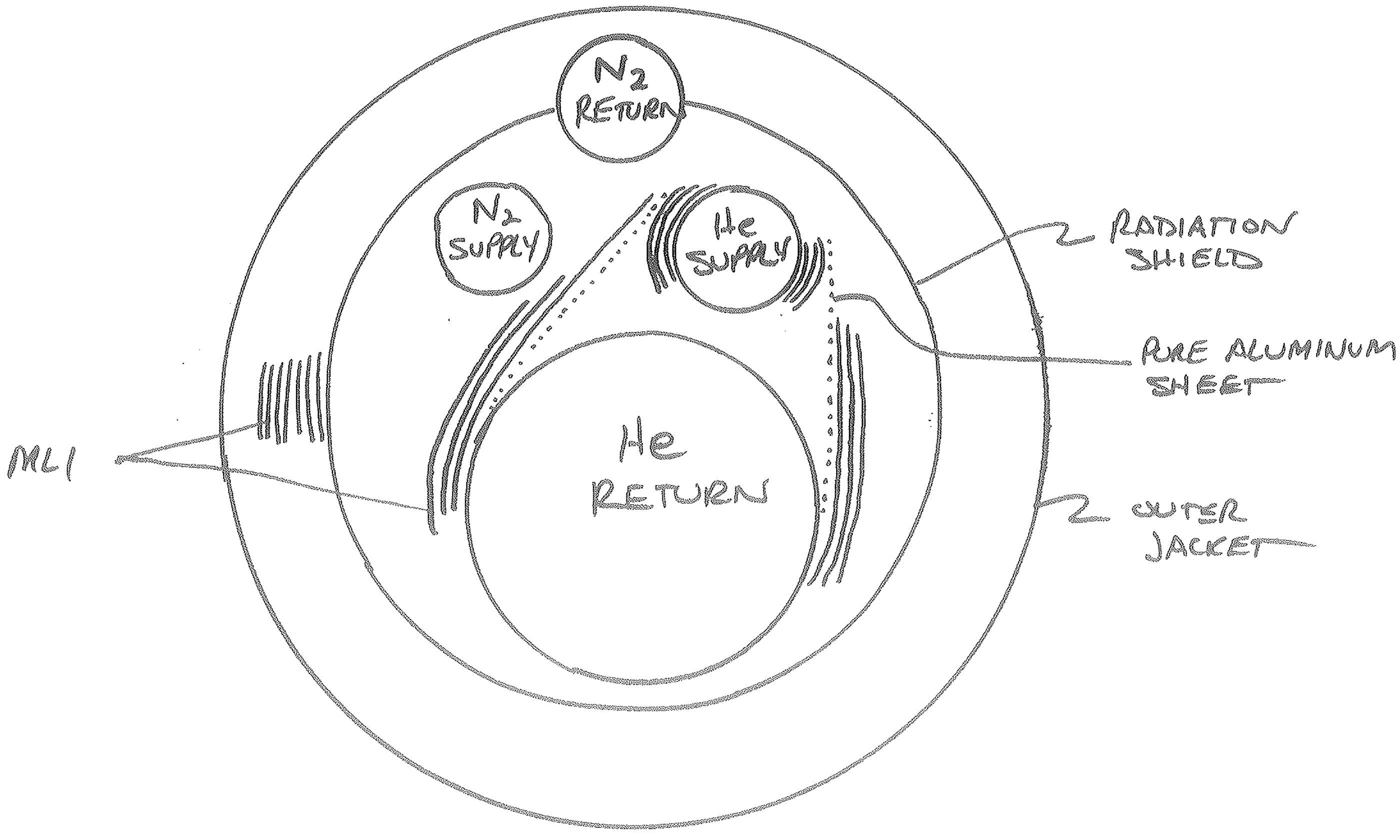
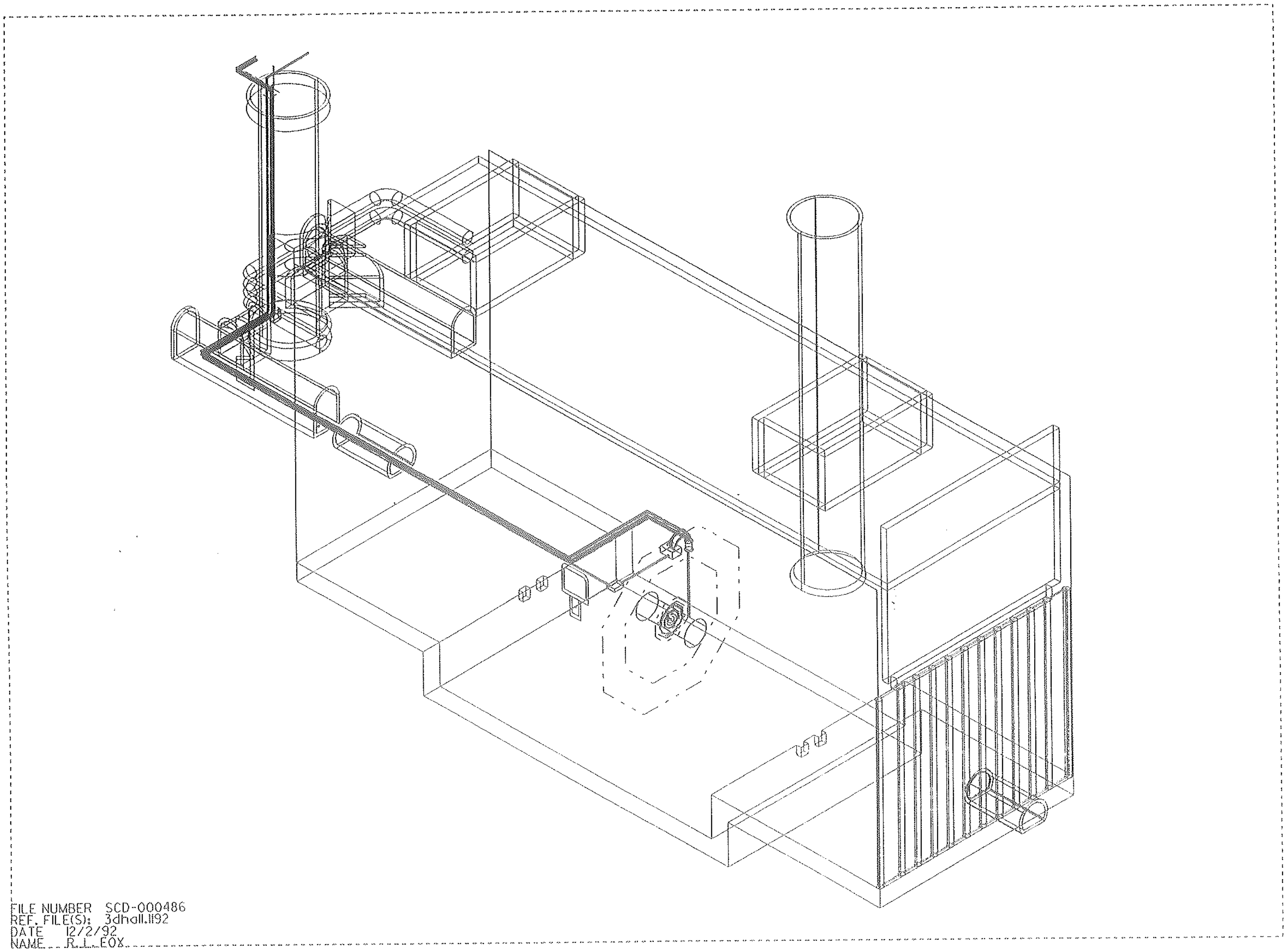
TRANSFER LINE CROSS SECTION





Transfer Line Route

Mode 2. Steady State Operation

Helium Circuit

Mass Flowrate		7 g/s
Helium Saturation Temperature in Solenoid		4.4 K
Total Equivalent Refrigeration Load at 4.2K		276 W
Solenoid and Chimney	40 W	
Vaporizing Heater	88	
Storage Dewar	3	
Transfer Line (supply)	7	
Transfer Line (return)	19	
Current Lead Flow (1 g/s ~ 119 W)	119	
Heater Power Input to Vaporize Liquid Fraction		88 W
Helium Quality After J-T Expansion		4 % vapor
Helium Quality at Solenoid Cooling Tube Outlet		34 % vapor
Initial Pressure Downstream of J-T Valve		1.17 atm
Pressure Drop in Cooling Tube		negligible
Pressure in Separator Vessel		1.17 atm

Nitrogen Shield Circuit

Mass Flowrate		6 g/s
Nitrogen Saturation Temperature in Solenoid Shield		82 K
Total Shield Refrigeration Load		1,230 W
Solenoid and Chimney	400 W	
Vaporizing Heater	625	
Transfer Line (supply)	5	
Transfer Line (return)	200	
Heater Power Input To Return Stream		625 W
Nitrogen Quality After J-T Expansion		11 % vapor
Nitrogen Quality After Exiting Service Port		45 % vapor
Shield Supply Pressure		3.2 atm
Pressure at J-T Valve		5.72 atm
Pressure Immediately Downstream of J-T Valve		1.6 atm
Pressure Drop in Shield Circuit		0.4 atm
Pressure at Service Port Outlet		1.2 atm
Nitrogen Vapor Temperature at Surface Vent		95.5 K

Mode 3. Coil Excitation (rampup or rampdown)

Helium Circuit

Mass Flowrate		23 g/s
Helium Saturation Temperature in Solenoid		4.4 K
Total Refrigeration Load at 4.2K		596 W
Solenoid and Chimney	130 W	
Vaporizing Heater	318	
Storage Dewar	3	
Transfer Line (supply)	7	
Transfer Line (return)	19	
Current Lead Flow (1 g/s ~ 119 W)	119	
Heater Power Input to Vaporize Liquid Fraction		318 W
Helium Quality After J-T Expansion		0 % (slight subcool)
Helium Quality at Solenoid Cooling Tube Outlet		30 %
Pressure Immediately Downstream of J-T Valve		1.22 atm
Pressure Drop in Cooling Tube		0.023 atm
Pressure in Separator Vessel		1.2 atm

Nitrogen Shield Circuit

Shield process conditions are identical to the steady state case.

CRYOGENICS COMMENTS FROM DOE REPORT

A. . . . The principal experience the participants have in cryogenics is with the CDF and TOPAZ systems, supplemented by one young engineer recruited from industry. The CDF system has never worked properly. It is therefore recommended that the cryogenic design and procurement of this system be "subcontracted" to the SSCL Accelerator Division, as they have much more expertise in both functions. Both capital and . . .

B. . . . The system is significantly oversized for its function. It was set at 1500 W to provide liquefaction recovery for two quenches per day, while supporting magnet ramping and the load from a VLPC system (which is not in the baseline design). A 750-W refrigerator would provide 16-hour recovery to initial conditions after a quench, including ramping and reliquefaction of 3000 liters of helium. On-site LHe inventory would allow for two quenches the first day and 1.5 per day thereafter in this scenario. This should be ample for this stable a magnet which will not move after installation. . . .

Method for Sizing a Cryogenic System for the SDC Thin Superconducting Solenoid Magnet

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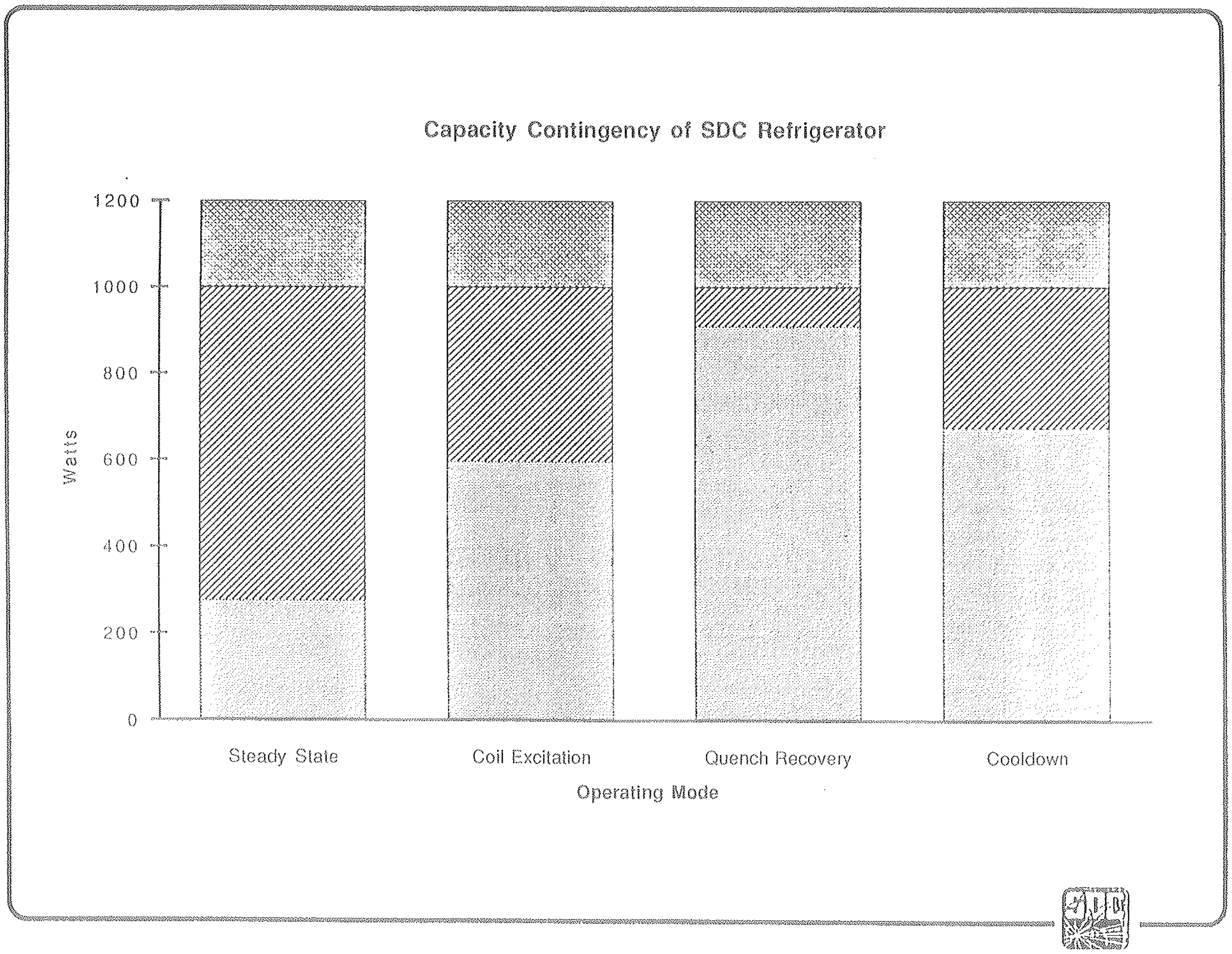
20 November 1992

1. Introduction

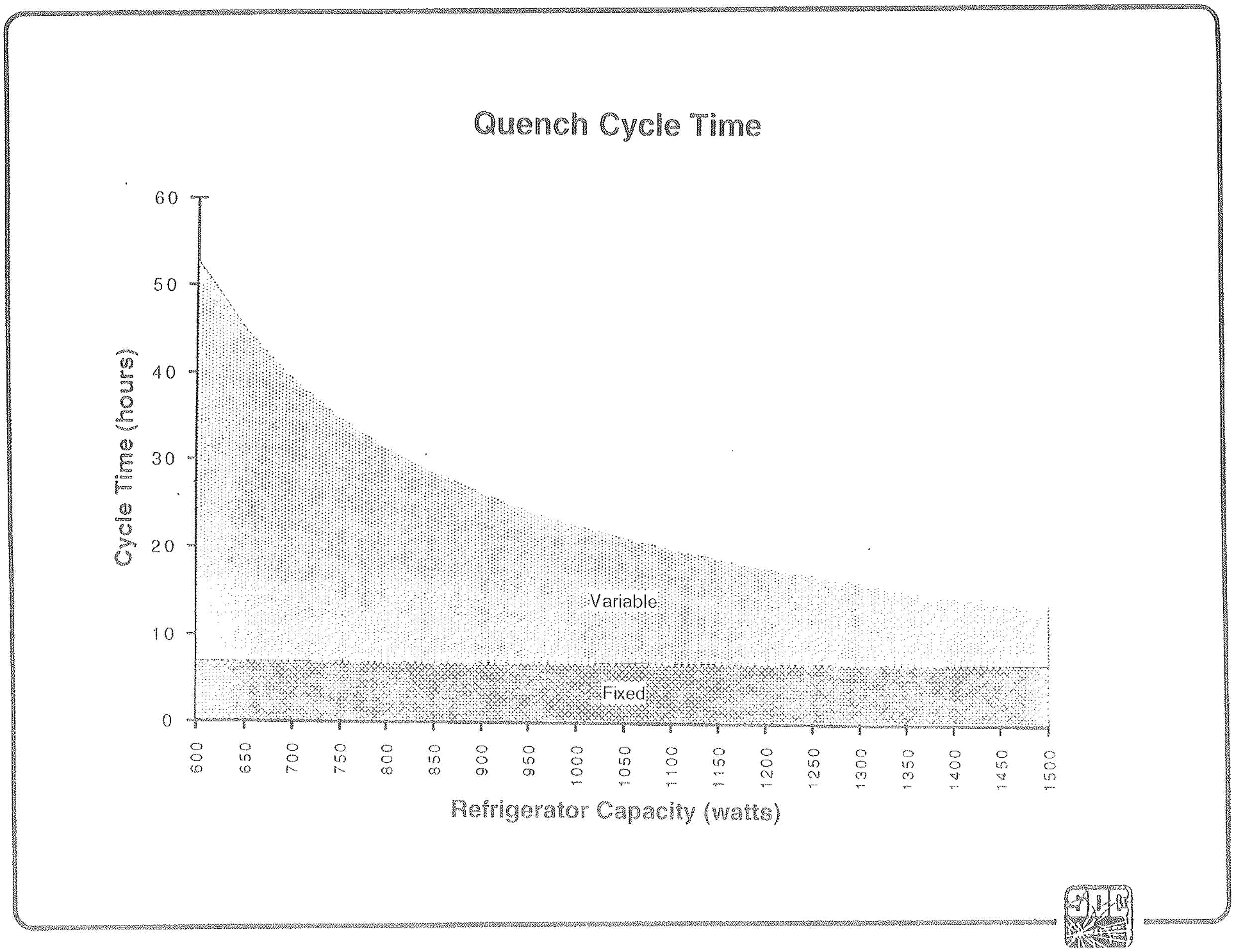
The thin superconducting solenoid magnet for SDC requires a cryogenic system to cool down to and maintain liquid helium temperature in the magnet cold mass. To meet the design and operational requirements described in the *Preliminary Design Requirements* document (4) for the cryogenics system, the system must have sufficient capacity to operate under the following operating modes:

1. Cooldown/Warmup
2. Steady State Operation
3. Coil Excitation (rampup or rampdown)
4. Quench Recovery

Each mode of operation places certain requirements on the system for 4K refrigeration capacity, warm gas liquefaction capacity, and mass flowrate. Helium refrigeration systems are commonly described by their 4K refrigeration capacity. This paper describes the method used to size the SDC cryogenic system and determine several important performance parameters.



Capacity Contingency of SDC Refrigerator
1200
1000
800
600
400
200
0
Watts
Steady State
Coil Excitation
Quench Recovery
Cooldown
Operating Mode


Quench Cycle Time
Cycle Time (hours)
60
50
40
30
20
10
0
Variable
Fixed
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
Refrigerator Capacity (watts)

Data to be presented at PDRR

Preliminary Design Requirements Review (PDRR)

The following items should be addressed, to the extent possible and relevant, during the PDRR. The objective is to ensure that the development requirements are defined and to adequately represent the requirements to begin the preliminary design.

- Subsystem block and functional diagrams
- Physics parameter analyses and simulation data
- Physics, engineering and construction requirements
- Risk and abatement strategy for cost, schedule and technical performance risks
- Draft Software Development Plan
- Specifications and Codes which affect design/construction/assembly/operation
- Reliability, maintainability, availability requirements
- Interface studies
- Status of Environmental, Health, and Safety requirements (A Draft Preliminary Safety Analysis Report (PSAR) is the basis.)
- Trade studies
- Quality control approach
- High level software requirements
- Test method(s)
- Computer system configuration/architecture
- Schedules
- Problems and concerns
- Assembly and installation requirements